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EXPORT ENHANCING EFFECTS OF INFORMATION AND COMMUNICATION TECHNOLOGIES: EVIDENCE FROM BANGLADESH

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ABSTRACT
The study examines the impact of information and communications technology (ICT) on bilateral export flows from Bangladesh to its trading partners based on an augmented panel gravity model. It includes 108 importers of Bangladeshi goods. The sample period extends from 2000 to 2018. Primarily, we employ Pooled Ordinary Least Square (POLS) model, and we utilize Poisson Pseudo Maximum Likelihood (PPML) as an alternative estimation technique to check robustness. The findings from the OLS model indicate that ICT has positive and significant effects on Bangladesh's bilateral export. The results from PPML also support the findings from the OLS model. Therefore, the results come out to be robust. These findings imply that by reducing trade-related costs e. g., shipping costs, market access costs, and communication and information costs, ICT growth in Bangladesh as well as in its trading partner countries enhances trade flows and therefore has a trade-boosting effect.

Contribution/Originality: While extant pieces of literature for Bangladesh on gravity model mostly explore the relationship between trade costs and trade flows, little attempt has been made to the studies of trade costs through the ICT infrastructure and trade. Therefore, this study sheds light on exploring the nexus between trade & ICT infrastructure in Bangladesh.

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1. INTRODUCTION
The use of Information and Communications Technology (ICT) has proliferated rapidly during the last two decades and ICT has become an integral part of our day-to-day activities across the globe. The ongoing 4th Industrial Revolution (4IR) coupled with a heretic working environment fabricated by the unprecedented COVID-19 pandemic has facilitated the growth of the ICT sector further. The impact of ICT revolution has been evident in international trade activities not only in developed economies but also in developing and under-developed economies.

The plethora of low-cost labor and favorable trade policies in Bangladesh have made the country a significant economic player in both the regional & international arena. Currently, trade or more precisely export is one of the significant economic factors in Bangladesh. In 2018, the total export amount of Bangladesh was $48.86bn, the lion's share of which came from goods export ($40.53bn) with a staggering $34.13bn export amount received from the apparel & clothing sector alone. Bangladesh had experienced a drop in the total export revenue earned in 2020 & 2021 compared to 2018 due to the COVID-19 pandemic. In 2020 Bangladesh had earned a total goods export revenue worth $32.6bn bouncing back in 2021 with an amount of $44.2bn. Apparently, it may seem that Bangladesh's export

revenue decreased drastically in 2020 but the situation is consistent with a 5.2% drop in global goods trade in 2020 as reported by World Statistics Review. During the 2008-2018 period, Bangladesh attained the second-fastest export growth worldwide (See Figure 1). The export value of apparel & garments from Bangladesh has increased more than 3 times just between the year 2008-2018 as Bangladesh holds the place for the second-largest apparel exporter with a 6.4% world trade share as reported in the annual report of the World Trade Organization (WTO).

Keeping the ICT prospects in mind, Bangladesh envisions a "Digital Bangladesh" with a staggering potential in ICT adoption rate. The relative rise in ICT adoption while other sectors stagnated during the global pandemic makes it more rational to concentrate on enabling ICT effects, particularly in trade and commerce. Vision 2021 being introduced in 2009, is the main driving force for the national development strategy of Bangladesh. which delineates a plan to fulfill the country's fundamental development goals. The goals envision an aspiring future for Bangladesh that ranges from "possessing an efficient, accountable, transparent and decentralized system of governance" to "a poverty-free middle-income economy" to "a globally integrated regional economic and commercial hub". The Government has deliberately put ICT as an impact factor to obtain these targets through a decisively planned program called "Digital Bangladesh" which encompasses four pillars: (1) Developing Human Resource (2) Digital Governance (public service delivery through the digital platform) (3) Linking citizens & (4) Introducing ICT in commerce.

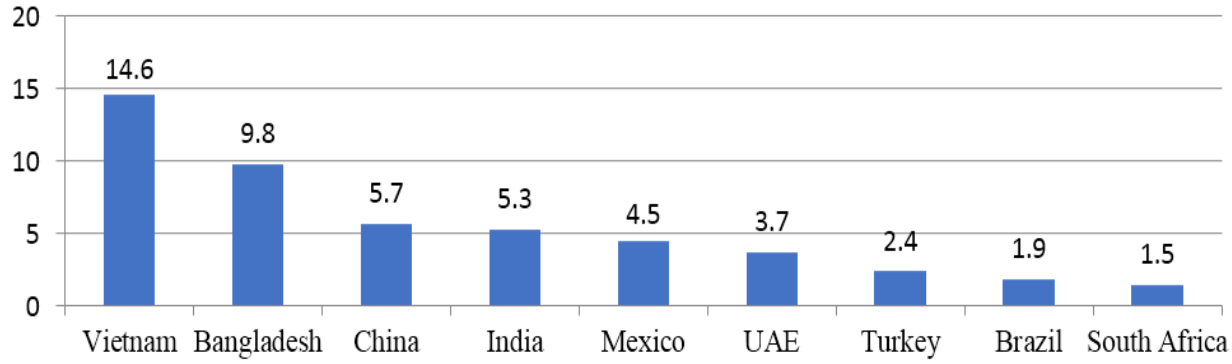

Figure 1. Growth in merchandising export, 2008-2018 (Average annual percentage change).
Source: WTO-UNCTAD.

The last pillar of the "Digital Bangladesh" program addresses three major components (Access to Information Program (A2I), 2009): (i) access to market (ii) promoting ICT business & (iii) developing ICT as an export-oriented phenomenon. Among all these sub-components facilitating access of the ICT-oriented marginalized suppliers to the market is the most fundamental one. The fundamental purpose of the second sub-component is to help the ICT industry so that it can provide the resources and technologies necessary to support the three other pillars of Digital Bangladesh. The third sub-component targets the mechanism to enable the ICT sector so that it appears export oriented. Several digitalization programs have been completed and, in continuation of this program, several others are underway. The National Digital Commerce Policy 2018 and the National ICT Policy 2018 have been prepared in response to the growing importance of the digital economy in Bangladesh. Table 1 provides the overall development of ICT infrastructure in terms of key ICT indicators.

Table 1. Bangladesh's key ICT indicators.

Year	Fixed-telephone users ('000s)	Fixed-telephone users (per 100 population)	Mobile cellular users ('000s)	Mobile cellular users (per 100 population)	Fixed broadband users	Fixed broadband users (per 100 population)	Percentage of individuals using the Internet
2010	1,281	0.85	67,924	46.02	414,569	0.27	3.7
2011	978	0.64	84,369	56.51	468,500	0.31	4.5
2012	962	0.62	97,180	64.35	600,461	0.39	5
2013	1,082	0.69	116,553	76.29	1,525,325	0.99	6.63
2014	974	0.61	126,866	82.1	3,093,171	2	13.9
2015	864	0.52	133,720	84.07	4,892,940	3.13	14.4
2016	766	0.48	135,9820	86.07	6.592.400	4.17	18.02
2017	707	0.44	1,509,450	94.52	7,300,500	4.57	15
2018	709	0.43	1,569,890	97.28	10,221,100	6.33	18

Source: International Telecommunication Union (ITU) and WDI database.

The Bangladesh government's motto, "Digital Bangladesh," is particularly important for national development and serves as a major stimulant for the use of ICT in international trade activities. At this point, research focusing on how ICT growth affects Bangladesh's trade performance is worth doing.

In this study, we aim to analyze the influence of ICT on the export of Bangladesh from the year 2000 to 2018 by using an augmented panel gravity model. With that goal, we choose 108 importing partners of Bangladesh. We

employ three ICT indicators as ICT proxies. This is the first-panel data research in Bangladesh to investigate the linkage between ICT & trade using a panel gravity model methodology. It makes policy recommendations for emerging nations with a similar economic development level as Bangladesh.

The rest of the paper is organized as follows. Section 2 provides an overview of Bangladesh's export scenarios. Section 3 gives the ICT policy reforms in the context of Bangladesh. Section 4 offers a literature review highlighting the previous gravity model research for Bangladesh. Section 5 explains the methodology. The results from the empirical analysis are presented in Section 6. Finally, section 7 offers a conclusion with a brief discussion of the study findings and a few important policy recommendations.

2. AN OVERVIEW OF BANGLADESH'S EXPORTS SCENARIOS

Since independence in 1971, Bangladesh retained a closed economy with a trade -GDP ratio of less than one-seventh (Taslim & Haque, 2011). Afterward, Bangladesh's commodity exports and imports have significantly increased in magnitude and variety. Throughout the 1970s, much of the country's exports were derived from jute and jute goods. During the 1972-73 fiscal year, Bangladesh's export turnover was only US$377 million which ascended to US$761 million by the end of the fiscal year 1979-1980 (Export Promotion Bureau, Bangladesh, henceforth, EPB).

It was the 1980s when a significant structural transition in exports of Bangladesh have been observed due to the growth in the ready-made garments (RMG) sector. The dramatic rise of exports - largely driven by the garment sector - created a highly concentrated export basket. This resulted in a rapid shift in trade policies to corroborate the transformation from an agricultural economy toward an industrial one. Later in 1990, Bangladesh steadily liberalized its trade policy as part of its structural reform program and stepped away from its import substitution policy to adopt an export-led development strategy. Subsequently, Bangladesh has lowered tariffs and non-tariff barriers; permitted duty-free capital equipment imports; introduced tax incentives for exported products; and adopted a flexible exchange rate regime (Hossain & Alauddin, 2005).

Since trade liberalization, overall exports have steadily expanded and the export–GDP ratio has escalated. However, the growth in exports has been heavily concentrated in the RMG sector, with little diversification. By 2019, total merchandise exports have met the mark of US$ 46364 million (see Table 2), which was exported internationally to over 150 countries. The export earnings of the country have been hovering around 15% of GDP on average for the last two decades signifying the extensive and mounting importance of the export sector in the national economy (see Table 2).

Table 2. Exports of Bangladesh from 2000 to 2019.

Year	Exports (in Million US$)	Growth Rate (%)	Exports as % of GDP
2000	6398.44	14.70	11.98
2001	6083.64	-5.17	11.26
2002	5989.42	-1.57	10.94
2003	6814.32	12.11	11.32
2004	7977.82	14.58	12.25
2005	9054.54	11.89	13.03
2006	11233.8	19.40	15.64
2007	12137.74	7.45	15.24
2008	15298.33	20.66	16.69
2009	15051.72	-1.64	14.68
2010	19209.41	21.64	16.66
2011	24537.2	21.71	19.07
2012	24904.21	1.47	18.67
2013	28638.19	13.04	19.09
2014	29924.49	4.30	17.30
2015	31736.04	5.71	16.26
2016	34122.05	6.99	15.41
2017	35300.77	3.34	14.13
2018	38687.14	8.75	14.11
2019	46364.21	10.94	15.32

Source: World Development Indicators, World Bank.

In 1972-73, jute and jute goods were the biggest contributors to export earnings, accounting for 38.5 percent and 51.4 percent of overall exports, respectively. Leather and leather goods, tea, and frozen food added 4.6%, 2.9%, and 0.9%, respectively. RMG's export share gradually grew, taking over the place of Jute and Jute products from 1991 to 1992.

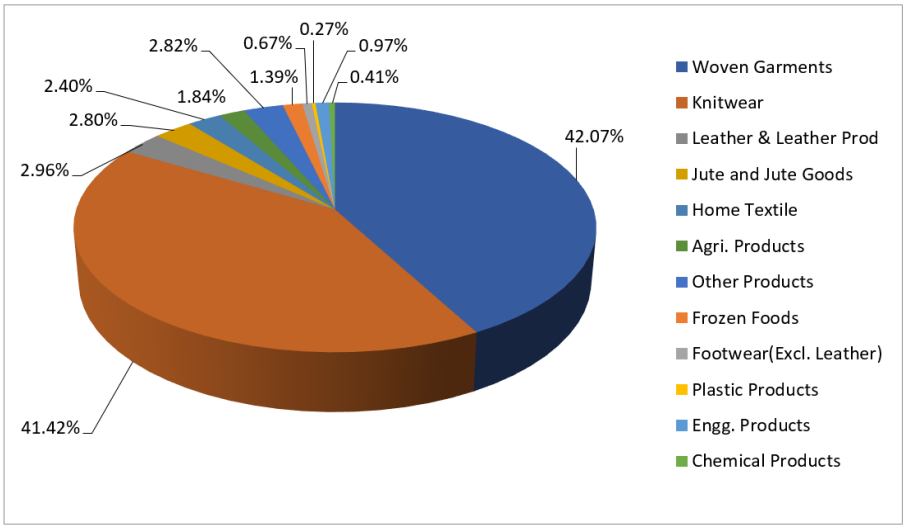

Figure 2. Bangladesh exports by major products during 2017-2018.
Source: Export Promotion Bureau (EPB), Bangladesh.

Since that time the exports share of tea, leather, and frozen foods started decreasing. From its modest start in the late 1970s, the RMG industry now accounts for over 75% of the country's overall exports. Therefore, it is apparent that Bangladesh's export framework has changed from heavy reliance on jute goods to RMG over the last four decades. The share of RMG and Knitwear in total exports increased from 1.2% in 1981 to about 40% in 1990, 76% in 2000, and 83% in 2018. In the total exports earnings of 2017-2018 woven garments and knitwear contributes 42.06% and 41.42%, respectively to the national exports (see Figure 2). The contributions of leather & leather products, jute and jute goods, home textile, agricultural products, and frozen foods are 2.96%, 2.80%,2.40%, 1.84%, and 1.39%, respectively (see Figure 2). Developing nations were the main buyers of Bangladesh's exports during the 1970s and early 1980s. This trend altered from the mid-1980s and sustained in the 1990s and beyond. In 1978, the developed countries accounted for 41.4% share of Bangladesh's exports and developing countries for 45.8% whereas, in 2002, developed countries emerged as dominating exports markets for Bangladesh's exports grabbing 88.3% and developing countries only 11.7% (Rahman & Dutta, 2012). It appears from Figure 3 that during the year 2017-2018, the USA stood first with 16.32% of Bangladesh's total exports earnings. Germany was second with 16.06% and the United Kingdom was in third place with 10.88% of total export earnings. The top ten importers of Bangladesh in the last ten years were the United States of America, Germany, United Kingdom, France, Spain, Netherland, Japan, Italy, Belgium, Canada, and Hong Kong.

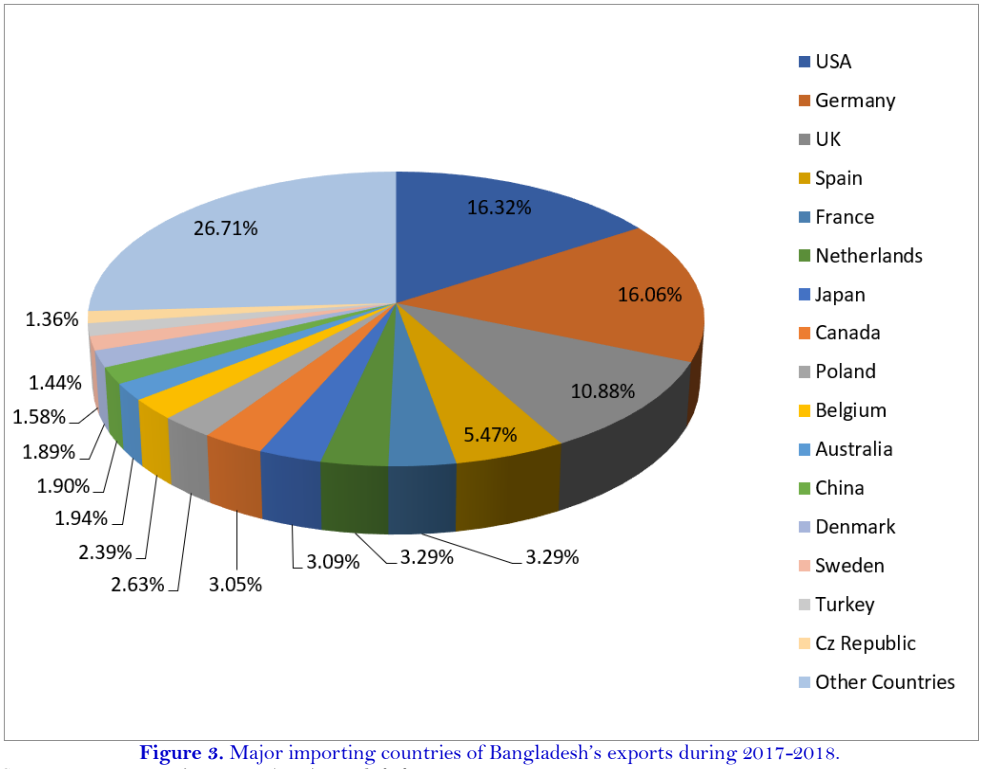

Figure 3. Major importing countries of Bangladesh's exports during 2017-2018.
Source: Export Promotion Bureau (EPB), Bangladesh.

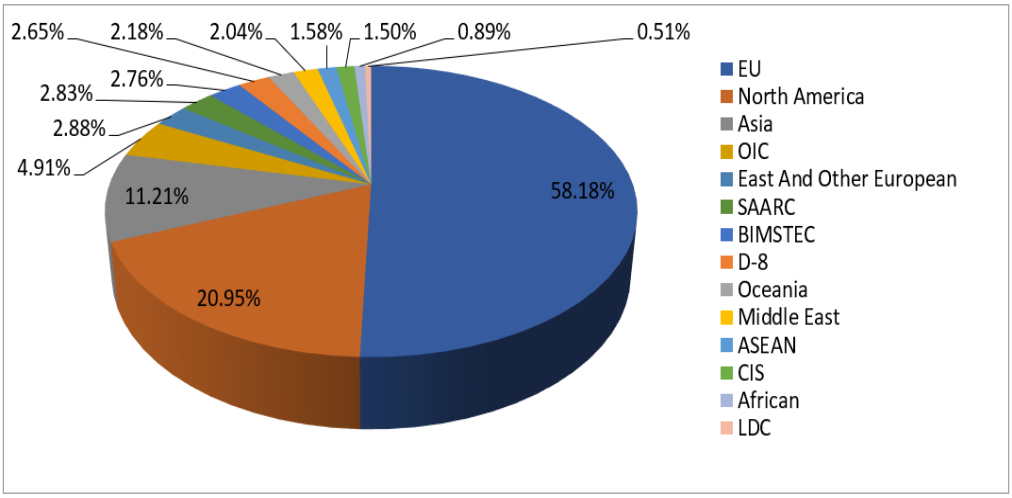

Figure 4. Direction of exports of Bangladesh by region.
Source: Export Promotion Bureau (EPB), Bangladesh.

Looking at the destination of Bangladesh's exports by key regions, we find that the main export destinations are European Union (EU) countries and the North American region followed by Asian and Middle Eastern regions. It appears from Figure 4 that between 2017 and 2018, the EU region stood first with 58.18% of Bangladesh's total export earnings. American Region was second with 20.95% and Asian Region was in the third place with11.21% of total export earnings. According to the statistics of EPB, Bangladesh earned 71.27% of the total exports from the USA, Germany, the UK, Spain, France, Italy, Canada, Japan, the Netherlands, and Poland in the fiscal year 2018-19.

3. ICT POLICY REFORM IN BANGLADESH

To accelerate the economic growth & uplift a large chunk of its population out of poverty, in recent years the government of Bangladesh has focused broadly on the development of the ICT sector and has taken a few perspective plans. Vision 2021, more commonly known as "Digital Bangladesh" is one of the several perspective plans that the government has taken with an ambition to rise as a middle-income economy within the year 2021. Vision 2021 aims to promote harmony, progress, and honor underscoring the application of digital technologies. The maxim 'Digital Bangladesh' aims to ensure access to information (a2i) for every citizen through extensive use of ICT to expedite economic development, growth & prosperity.

Table 3. Reform of ICT policies & laws over the period in Bangladesh.

Name of the Policy/Act	Year of Enactment	Targets
Digital Security Act	2018	Detection, prevention, restraint, and judgment of issues related to national digital security and cybercrime.
Digital Security Act	2016	Ensuring & establishing the security of ICT.
Hi-tech Park Authority Act	2010	Enhancing Bangladesh's hi-tech industries & businesses.
Access 2 Information (a2i) & National ICT policy	2009	Ensuring easy access to the internet with efficient service. Empowering citizens with the legal right to look for any information. Providing an updated and complete plan for the development of ICT consistent with the vision of Digital Bangladesh.
ICT Act	2006	Guaranteeing that information and communication technology is legally recognized and secured.
Copyright Amendment Act	2005	Protecting intellectual property rights.
National ICT Policy	2002	Encouraging & enabling the use of ICT across all sectors, as well as ensuring transparent and efficient governance.
Bangladesh Telecommunications Act	2001	Forming an autonomous commission for facilitating telecommunication services.
National Telecommunications Policy (NTP)	1998	Ensuring the fast growth of telecommunications to expedite the social & economic development.

Source: Collected from ICT Division, Ministry of Posts, Telecommunications & Information Technology; Bangladesh Telecommunication Regulatory Commission (BTRC).

To meet the targets of perspective plan 2021, the government had specially enacted "The National ICT Policy 2009". "The National ICT Policy-2009" amass of 306 action plans, divided into the different time frames, had been formulated to expedite achieving these goals under Vision 2021. One of the key objectives of the policy was to earn the tag of a middle-income economy within the year 2021 & develop country status by 2041. The government introduced the Public-Private Partnership (PPP) model to accelerate the growth of ICT infrastructure and public services, resulting in an increase in ICT investment shares from about 2% to 6% of the country's total GDP (Rogers,

2018). The National ICT Policy (NIP) has been a flagship of the government's legislative mechanism for ICT development in Bangladesh. As a policy commitment, Bangladesh government has set up a vast network of 4500 Union Digital Centers (UDC) throughout the country to ensure rural people have access to IT services (ITU, 2018). The Access to Information (A2I) initiative is intended to enhance the efficiency and ease of access to decentralized administrative services for the people of Bangladesh (Access to Information Program (A2I), 2009).

The NIP was first adopted in October 2002, followed by modification and amendment in 2008, 2009, and 2015, respectively. Finally, in 2018, in the wake up of the emergence of 5G technology and the fourth industrial revolution, the government revised and amended it with a significant adjustment introducing 55 strategic themes and 343 action plans/items (ICT Division, 2019). The NIP is designed and formulated by the "ICT Division". "The Ministry of Posts, Telecommunication, and Information Technology (MoPTIT)" has two divisions that facilitate all major ICT initiatives and digital agenda in Bangladesh, the Posts and Telecommunications Division and the ICT Division.

4. LITERATURE REVIEW

Human interaction and international trade among countries have massively changed over the past couple of decades, thanks to the extensive use of ICT especially the high level of internet usage among all the countries. This phenomenon is often called the ICT revolution. This ICT revolution has been evident in international trade activities not only in developed economies but also in developing and under-developed economies. It has impacted business transactions between these groups of countries to a great extent. ICT system helps customers and suppliers to communicate faster, reducing fixed entry costs related to markets (Freund & Weinhold, 2004; Lin, 2015), such as search costs, advertising costs, and the costs of creating a supply network in a market. Using ICT networks, business partners and workers can be tracked more effectively, resulting in a smaller amount of administration and control costs, and therefore, information; communication, and collaboration costs can be reduced. Related research exhibiting a positive nexus between international trade and ICT has therefore been increasing (Ahmad, Ismail, & Hook, 2011; Barbero & Rodriguez - Crespo, 2018; Choi, 2010; Clarke & Wallsten, 2006; Freund & Weinhold, 2004; Lin, 2015; Liu & Nath, 2013; Mattes, Meinen, & Pavel, 2012; Rodriguez-Crespo, Billon, & Marco, 2021; Rodriguez-Crespo, Marco, & Billon, 2018; Rodríguez-Crespo & Martínez-Zarzoso, 2019; Vemuri & Siddiqi, 2009; Wang & Li, 2017).

4.1. Previous Gravity Model Research for Bangladesh

The gravity model application to the literature in the case of Bangladesh is quite limited. Rahman (2010) used the panel data estimation method and a generalized gravity model to identify the responsible variables for Bangladesh's export. The results of the regressions show that the most important contributors to the exports of Bangladesh are the exchange rate, the overall import demand of partner countries, and Bangladesh's trade openness to the international market. Rahman and Ara (2010) examine the trade potential of Bangladesh with its main trade partners by employing a dynamic gravity panel model. Their findings reveal that a big portion of potential trade of Bangladesh has been left unrealized. In general, there is a high trade flow between Bangladesh & larger economies as suggested by the estimated findings. Rahman and Dutta (2012) used the panel data estimation to assess the bilateral trade value of Bangladesh with its partner by employing a generalized gravity model. The findings show a favorable impact of the partner countries' GDPs, GDP per capita differentials, and trade openness on Bangladesh's trade. Wages, total import demand from partner nations, and openness all influence exports positively, although there is a negative impact of inflation & income level of partner countries. Husain and Yasmin (2015) used the data of fifty-two major trading partners of Bangladesh & followed the panel gravity model approach to examine the factors affecting Bangladesh's bilateral trade flows. Here the authors had used the panel data from the year 1975 to 2005 & the outcome was generated by using fixed effect, pooled OLS & random effect technique. Hassan (2017) analyzed the export performance and the level of efficiency for trade between Bangladesh and her forty trade partners by identifying the factors affecting the bilateral trade for a panel data from the period 2008 to 2011 the authors had used likelihood estimation technique & Stochastic frontier gravity model (SFGM). The findings of this paper exhibit that Bangladesh's exports are positively affected by exchange-rate depreciation, GDP, population & trade agreements, but negatively affected by the tariff levels and the distance between Bangladesh & its partner countries. The findings also show that 'behind-the-border' socio-political-institutional restraints, for instance, custom formalities, inefficient port management & corruption, frustrate trade. Rahman, Shahriar, and Kea (2019) examine the issues & identify the determinants that influence Bangladeshi clothing & textile export. This paper also uses a panel gravity model approach to identify the factors affecting the export of textile & clothing. The finding of this paper is commensurate with the theoretical framework of the gravity model which exhibits a positive impact of the size of the GDP of trading countries on their trade. The authors also included a few dummy or categorical variables to examine the impact of regional trade block on the clothing & textile exports of Bangladesh & the result shows that a significant portion of Bangladesh's export finds its way to those countries who are the members of NAFTA (North American Free Trade Agreement) & EU (European Union). Shahriar, Kea, Abdullahi, Rahman, and Islam (2021) followed the panel gravity model approach to determine the factors affecting the amount of leather export from Bangladesh to its major trade partners. The authors identified that the level of transport costs is the most significant impediment of export that frustrate the economic growth. The complex cross-border trading practices lead to high trading costs in Bangladesh as the finding of this paper suggests. To overcome these cumbersome trading practices, the authors suggested facilitating the use of technology which is in line with our key research question that how the use of ICT can enhance the export scenario in Bangladesh. While Bangladesh's previous gravity literature has been recognized for exploring the relationship between trade costs and trade flows, there has been a lack of studies of trade costs through the ICT infrastructure and trade. Therefore, this study focuses on exploring the nexus between trade & ICT

infrastructure in Bangladesh by using the trade data of Bangladesh & its trading partners from the years 2000 and 2018 through a panel gravity model approach.

5. METHODOLOGY

5.1. Model Specification

To investigate the effect of ICT on exports the study rests on the gravity model taking 108 partner countries of Bangladesh exports over the period 2000 to 2018. The gravity model is universally used in studying international trade literature since the technique has been found to be effective to explain the key association between trade costs and bilateral trade flows. The idea of the model was derived from Newton's Universal Gravitational Law of Physics. Based on Newton's initial intuition, Timbergen (1962) and Poyhönen (1963) employed this framework to economics that confirms bilateral trade flows between two countries as an increasing function of country size (usually GDPs) and decreasing in terms of the geographical distance between the countries. This relationship derived from intuition is commonly known as the basic gravity model of trade which can be denoted as follows:

$$X_{ij}=\frac{YiYj}{Dij} \quad (1)$$

Where subscripts i and j stand for exporter and importer country correspondingly. X*ij* denotes bilateral exports from country i to j, YiYj is the product of incomes of i and j and Dij refers to the physical distance between i and j. This equation can be easily log-linearized, which we express as follows:

$$\ln X_{ij} = \beta_0 + \beta_1 \ln Y_i + \beta_2 \ln Y_j + \beta_3 \ln D_{ij} \quad (2)$$

The natural logarithm has been employed in Equation 2 where, βs are parameters of elasticity that summarize the impact of GDP of exporter as well as importer, and distance on exports. However, additional variables, both time-invariant and time-varying export determinants (either stimulating or restricting) are usually added to empirical gravity. To measure the impacts of ICT on exports from Bangladesh to its trading partners, we use the trade gravity modeling technique and incorporate the ICT variable in the model. The model can be stated as follows:

$$\text{Ln } Exp_{ijt}=\alpha_0 + \beta_1 \ln ICT_{i,t-1}+\beta_2 \ln(ICT_{i,t-1}*ICT_{j,t-1})+\beta_3 \ln(GDP_{it}*GDP_{jt})+ \beta_4 \ln DIST_{ij} + \beta_5 RTA_{ij,t-1} + \beta_6 COMBOR_{ij} + \beta_7 LANDLOCKED_j + \beta_8 EU_j + \beta_9 NAFTA_j + \beta_{10} BRICS_j + \varepsilon_{ijt} \quad (3)$$

Where i and j denote Bangladesh and its export partners respectively and t denotes time. Expijt indicates the export flows to country j from Bangladesh in time t. ICTi,t-1 is the level of ICT of Bangladesh lagged by one year. (ICTi,t-1*ICTj,t-1) is the level of ICT mass lagged by one year that measures the ICT level of Bangladesh and its trading partner country j which is expected to have positive effects on exports of Bangladesh. As proxies for ICT, we use three ICT indicators: (1) Internet users per 100 people, (2) Fixed broadband subscriptions per 100 people, (3) Mobile phone subscriptions per 100 people. (GDPit*GDPjt) refers to the GDP mass that measures the product of the economic size of Bangladesh and its export partner country j. This is anticipated to give positive impacts on export. DISTij is the physical distance between Bangladesh and country j. RTAij,t-1 is a one-year-lagged binary dummy variable taking the value 1 if Bangladesh and its export partner are part of any bilateral or regional trade agreement (RTA) in some periods of time and 0 otherwise. COMBORij is a binary dummy variable that takes the value of 1 if Bangladesh and country j share a common border and 0 otherwise. LANDLOCKEDj is a binary dummy variable taking the value of 1 if Bangladesh's export partner j is a landlocked country and 0 otherwise. EUj is a dummy variable that takes the value of 1 if country j is a member of the European Union. NAFTAj is a dummy variable that takes the value of 1 if country j is a member of NAFTA. BRICSj is a dummy variable that takes the value of 1 if country j is a member of BRICS. Finally, εijt is an error term that is assumed to be normally distributed with zero means. It might be the case that ICTs and exports have a mutual effect on each other (reverse causality). Several studies find that technology adoption is expedited due to international trade (Bustos, 2011; Caselli & Coleman, 2001; Lileeva & Trefler, 2010; Rodrik, 2011). To address endogeneity, the ICT variable is lagged by one year and then incorporated in the regression model. One of the arduous challenges of the gravity framework is determining a consistent estimate of the effects of trade agreements since the trade agreements variables RTAij,t, and εij,t are endogenous (Baier, Bergstrand, & Feng, 2014). For example, trade agreement variables may experience the issue of "reverse causality", because countries are prone to make their trade policy more liberalized with those regions with which they are already in a good trade relationship, other things remaining the same (Krishna, 2005). The regional trade agreement variable is also included with one year lag in response to the potential endogeneity issue.

5.2. Data

Bilateral goods exports (in current US dollar) data are collected from the Direction of Trade Statistics (DOTS) database of IMF. Data for the ICT variables are taken from the World Bank and International Telecommunication Union (ITU) database. GDP measured in current US dollars is attained from the World Development Indicators (WDI) database of the World Bank. CEPII Gravity data set is the source of variables such as distance, contiguity (common border); landlocked which capture natural trade barriers. Variable indicating whether Bangladesh and its trading partners are members of a bilateral or regional trade agreement (RTA) that covers trade in goods are made available by the WTO RTA database. Dummy variables whether Bangladesh's trading partners are members of EU, NAFTA, and BRICS are also derived from the WTO RTA database.

5.3. Estimation Strategy

Unifying both time series and cross-sectional data, the panel data yields more relevant data with higher degrees of freedom, low level of collinearity, high-efficiency level & variability. There are several regression techniques particularly formulated for panel data, for instance, ordinary least squares (OLS) estimation, random effect model

(REM), and fixed-effect model (FEM) are used by researchers to estimate the outcome of a gravity panel model. Panel OLS assumes that there is no discrete heterogeneity in the model while this estimation technique ignores the time & space dimension. In many panel data studies, the gravity equation is regularly log-linearized as in Equation 3 and ordinary least square is the usual practice of estimation technique in that case. While this practice offers a robust result based on the homoscedastic assumption, it suffers from flaws. The official data on bilateral trade contain a substantial proportion of zero flows. Log transformation of the zero trade flows may lead to sample selection bias since the log of zero is not defined. The fixed-effect model presumes that there is a correlation between the unobserved heterogeneity and the error term. The fixed-effect model (FEM) exhibits some drawbacks in the sense that while we perform an analysis by using FEM, all time-invariant variables (which appear to be perfectly collinear with the fixed effects) would be dropped from the model. Hence, there is the problem of elimination of several important variables from the gravity equation, that are pertinent to the theoretical model of a particular study. The geographical distance between countries, common border of trading partners, whether the trading partner country is landlocked or not are a few of the time-invariant variables in the present study the effects of which cannot be established, hence panel FEM is not relevant to the present study. The panel REM technique posits that we randomly draw individual cross-sectional units with a constant mean from a large population. The REM estimation technique is also known as the error component model since it apprehends the individual heterogeneity, which is a divergence from the constant mean value by a component in the composite error term. The REM estimators will become biased & inefficient if the individual error component of one or more regressors is correlated to one another Greene (2002). Hence, we will end up with biased estimates because of the autocorrelation problem as we connect unobserved heterogeneity with the error component while using the REM technique.

In this study, both OLS and PPML have been used as estimation techniques. OLS is used since the data set is free from the issue of zero trade flows. We also take the nonexistence of unobservable heterogeneity into account to corroborate the OLS estimation. As an alternative estimation technique, the PPML model is applied to avoid the complications of multicollinearity, heteroscedasticity, and autocorrelation. For gravity trade model studies, the PPML is regarded as the most appropriate estimation technique since it is systematically unbiased and consistent (Alvarez, Barbero, Rodríguez-Pose, & Zofío, 2018). Kabir, Salim, and Al-Mawali (2017) underscore the use of the PPML technique to get a congruous & compatible gravity estimation. PPML is recommended by some researchers to produce robust and unbiased results (Haq, Meilke, & Cranfield, 2013; Magerman, Studnicka, & Van Hove, 2016). In fact, it has been widely employed in the estimate of gravity equations (Bosquet & Boulhol, 2015; De Sousa, 2012; Egger & Tarlea, 2015; Larch, Wanner, Yotov, & Zylkin, 2019; Rodríguez-Crespo. & Martínez-Zarzoso, 2019; Shahriar, Qian, & Kea, 2019).

The dependent variable in the case of the PPML regression is framed as exports in levels in lieu of logarithms as exhibited in Equation 4. We can still interpret the coefficient of any independent variables as simple elasticities present in logarithmic form.

$$Exp_{ijt}=\exp(\alpha_0 + \beta_1 \ln ICT_{i,t-1} + \beta_2 \ln(ICT_{i,t-1} * ICT_{j,t-1}) + \beta_3 \ln(GDP_{it} * GDP_{jt}) + \beta_4 \ln DIST_{ij} + \beta_5 RTA_{ij,t-1} + \beta_6 COMBOR_{ij} + \beta_7 LANDLOCKED_j + \beta_8 EU_j + \beta_9 NAFTA_j + \beta_{10} BRICS_j + \varepsilon_{ijt}) \quad (4)$$

6. RESULTS

Appendix Table A1 provides the narrative of the variables and sources of data and Table A2 portrays the statistical summary of the variables used in the regressions. Table 4 and Table 5 report the estimation outcomes applying the Ordinary Least Square (OLS) and the Poisson Pseudo Maximum Likelihood (PPML) estimation techniques, respectively. Both tables report the regression results for three ICT indicators: Internet users per 100 people (column 1 & 2); fixed broadband subscriptions per 100 people (column 3 & 4) and mobile phone subscriptions per 100 people (column 5 & 6). The selected indicators of the ICT variable are regressed separately to see which indicator of the ICT plays a more significant role for exports in Bangladesh. Columns 1, 3, and 5 in both tables provide the export enhancing effects of internet use, broadband, and mobile phones in Bangladesh. Columns 2, 4, and 6 provide the results for the combined effects of Bangladesh and its trading partners' internet, broadband, and mobile phones on Bangladesh's exports.

Overall, Bangladesh's merchandise exports to the trading partners are well explained with the results obtained from the gravity model specification, having coefficients with signs and magnitudes largely consistent with economic predictions and statistical significance.

The results registered in Table 4 provide clear evidence that there lies a positive and significant impact of Internet, broadband, and mobile phones on Bangladesh exports. In the case of the impact of Bangladesh's ICT on its exports, we find that the internet (column 1) and mobile phones (column 3) show positive and significant impact on exports while broadband (column 5) shows only positive but not significant impact. With regards to combined effects (columns 2, 4, and 6), all the ICT indicators show positive and significant impacts on Bangladesh's exports. Thus, the findings confirm the underlying hypothesis of the study that ICT reduces trade costs.

Expectedly, the bilateral export of Bangladesh is impacted positively and significantly from the GDP mass variable in all the regressions, proving the fact that the economic size of country pairs is an enhancing factor for export. As expected, the distance between Bangladesh and its exporting partners affects Bangladesh's export negatively. The larger the distance between Bangladesh and its partners, the lower is the export from Bangladesh to those countries. As far as binary dummy variables are concerned, the RTA seems to have, as expected, a positive and significant effect on Bangladesh's exports to its trading partners. The impact of sharing a common border on Bangladesh's exports is negative and significant.

Table 4. The results of ICT and Bangladesh's exports (OLS model).

Variables	Internet Use		Broadband		Mobile	
	1	2	3	4	5	6
$lnIU_{i,t-1}$	0.081*** (0.024)					
$ln(IU_{i,t-1}*IU_{j,t-1})$		0.045*** (0.016)				
$lnBRB_{i,t-1}$			0.046 (0.029)			
$ln(BRB_{i,t-1}*BRB_{j,t-1})$				0.055*** (0.021)		
$lnMOB_{i,t-1}$					0.072*** (0.022)	
$ln(MOB_{i,t-1}*MOB_{j,t-1})$						0.032** (0.015)
$Ln(GDP_{it}*GDP_{jt})$	0.689*** (0.029)	0.681*** (0.031)	0.664*** (0.038)	0.635*** (0.041)	0.691*** (0.030)	0.703*** (0.030)
$lnDISTANCE_{ij}$	-0.925*** (0.049)	-0.939*** (0.049)	-0.765*** (0.062)	-0.798*** (0.061)	-0.925*** (0.049)	-0.921*** (0.049)
$RTA_{ij,t-1}$	0.125* (0.075)	0.146* (0.076)	0.200** (0.098)	0.316*** (0.099)	0.125* (0.075)	0.122 (0.075)
$COMBOR_{ij}$	-0.852*** (0.132)	-0.861*** (0.134)	-0.842*** (0.169)	-0.914*** (0.170)	-0.851*** (0.132)	-0.888*** (0.133)
$LANDLOCKED_{j}$	-0.736*** (0.121)	-0.628*** (0.126)	-0.691*** (0.143)	-0.663*** (0.155)	-0.736*** (0.121)	-0.646*** (0.125)
EU_{j}	1.945*** (0.144)	1.933*** (0.143)	2.224*** (0.170)	2.211*** (0.171)	1.944*** (0.143)	1.921*** (0.143)
$NAFTA_{j}$	2.710*** (0.189)	2.705*** (0.189)	2.761*** (0.230)	2.769*** (0.236)	2.703*** (0.188)	2.646*** (0.191)
$BRICS_{j}$	1.092*** (0.120)	1.086*** (0.122)	1.584*** (0.135)	1.578*** (0.131)	1.088*** (0.121)	1.043*** (0.123)
Constant	-25.32*** (1.524)	-24.89*** (1.628)	-25.34*** (1.981)	-23.67*** (2.151)	-25.56*** (1.496)	-26.18*** (1.562)
Observations	1,760	1,752	1,081	1,060	1,760	1,756
R-squared	0.576	0.575	0.554	0.564	0.575	0.575

Notes: Robust standard errors in parentheses. ***, **, and * denote statistical significance at 1%, 5%, and 10%, respectively.

As Bangladesh does not have a shared border with most of its importers, such as EU member countries, this is not an unusual outcome. As predicted, Landlocked has had a negative effect on Bangladesh's bilateral exports. This finding means that owing to higher shipping prices, Bangladesh sells less to its landlocked trade partners. EU, NAFTA, and BRICS all are significant with a positive sign. The countries of the European Union are now Bangladesh's largest trading partners. As a single nation, NAFTA member USA is Bangladesh's largest importing country.

We use a different estimation tool, the Poisson pseudo maximum likelihood (PPML), developed by Silva and Tenreyro (2006), to verify the robustness of the OLS outcomes. PPML results reported in Table 5 reveal that all ICT indicators have positive and significant impacts on Bangladesh's exports at different significance levels, suggesting the robustness of the impact of ICT on Bangladesh's exports.

However, the magnitudes of the coefficients of the ICT indicators are a little different from those of the OLS estimation. It should be noted that PPML and OLS are two different estimation techniques, and hence their coefficients do not have to be precisely the same. As regards to other variables, GDP remains positive and significant. Distance keeps its negative impact on exports. All the dummy variables considered in the study seem to be economically and theoretically consistent except for the regional trade agreement which changes its sign under PPML. Overall, the robustness of the OLS conclusions is demonstrated by this alternative estimator. Based on these findings, it is possible to conclude that information and communication technology (ICT) is a key component in boosting bilateral trade between Bangladesh and its trading partners. ICT promotes Bangladesh's international trade by lowering trade-related costs such as transportation, information, and communication costs.

Table 5. The results of ICT and Bangladesh's exports (PPML model).

Variables	Internet Use		Broadband		Mobile	
	1	2	3	4	5	6
$\ln IU_{i,t-1}$	0.190*** (0.0389)					
$\ln(IU_{i,t-1}*IU_{j,t-1})$		0.093*** (0.028)				
$\ln BRB_{i,t-1}$			0.088** (0.039)			
$\ln(BRB_{i,t-1}*BRB_{j,t-1})$				0.055* (0.030)		
$\ln MOB_{i,t-1}$					0.197*** (0.040)	
$\ln(MOB_{i,t-1}*MOB_{j,t-1})$						0.139*** (0.033)
$\ln(GDP_{it}*GDP_{jt})$	0.298*** (0.048)	0.308*** (0.048)	0.301*** (0.056)	0.362*** (0.049)	0.301*** (0.048)	0.297*** (0.050)
$\ln DISTANCE_{ij}$	-0.190* (0.104)	-0.228** (0.103)	-0.164 (0.113)	-0.146 (0.122)	-0.191* (0.104)	-0.214** (0.104)
$RTA_{ij,t-1}$	-0.635*** (0.147)	-0.570*** (0.141)	-0.568*** (0.161)	-0.550*** (0.163)	-0.632*** (0.146)	-0.611*** (0.145)
$COMBOR_{ij}$	-2.116*** (0.161)	-2.136*** (0.164)	-2.083*** (0.187)	-2.031*** (0.185)	-2.112*** (0.160)	-2.145*** (0.163)
$LANDLOCKED_j$	0.657** (0.311)	0.702** (0.309)	0.590* (0.332)	0.504 (0.370)	0.657** (0.313)	0.772** (0.316)
EU	2.133*** (0.134)	2.110*** (0.133)	2.113*** (0.151)	2.142*** (0.163)	2.133*** (0.134)	2.115*** (0.133)
NAFTA	2.655*** (0.218)	2.591*** (0.212)	2.521*** (0.246)	2.403*** (0.238)	2.648*** (0.216)	2.679*** (0.223)
BRICS	0.978*** (0.188)	0.957*** (0.188)	1.043*** (0.205)	0.952*** (0.219)	0.971*** (0.190)	0.937*** (0.190)
Constant	-10.04*** (2.606)	-10.49*** (2.667)	-10.05*** (3.090)	-13.33*** (2.802)	-10.64*** (2.545)	-10.65*** (2.618)
Observations	1,760	1,752	1,081	1,060	1,760	1,756
R-squared	0.496	0.498	0.480	0.490	0.503	0.506

Notes: Robust standard errors in parentheses. ***, **, and * denote statistical significance at 1%, 5%, and 10%, respectively.

7. CONCLUSION

By means of an augmented panel gravity model, we study ICT's impact on bilateral merchandise export flows from Bangladesh to its 108 trading partners for a sample period extending from 2000 to 2018. As an estimation tool, we utilize the pooled OLS and employ the PPML methodology as an alternative estimation method to verify the robustness and validity of the results. As proxies for the ICT variable, we use three ICT indicators including 'Internet users per 100 people', 'Fixed broadband subscriptions per 100 people', and 'Mobile phone subscription per 100 people'. The results of the OLS model confirm the positive and significant impact of ICT on bilateral exports from Bangladesh. The PPML results also verify the findings of the OLS model indicating the robustness of the results. It should be noted that the findings are in line with those of the preceding literature. These findings suggest that ICT growth in Bangladesh and its trading partner countries is important in enhancing the exports of Bangladesh. As documented, the previous literature confirms that ICT boosts trade by lowering trade costs like transport costs, search costs, entry costs into the markets, information costs, and communication costs. Bangladesh is no exception in the exploitation of the trade-boosting effect of ICT. There are various policy implications for Bangladesh following the findings of the paper though the responsibility of improving ICT rests upon its respective trading partners. For example, Bangladesh should concentrate on developing its trade relationship with countries that are endowed with better ICT infrastructure. Particularly, Bangladesh will be able to foster its bilateral exports through trade relations with countries with a higher level of ICT endowments. It is proposed that the government and private as well as public organizations should exert more emphasis on ICT sector development in Bangladesh.

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APPENDIX

Table A1. Variable definition and sources.

Variable	Definition	Units of measure	Sources
Exp_{ijt}	the volume of export from Bangladesh to country j in period t	Current USD (million)	Direction of Trade Statistics (DOTS), IMF
ICT			
IU_{it}, IU_{jt}	Internet users of Bangladesh and country j in year t	Users per 100 inhabitants	ITU (International Telecommunication Union)
MOB_{it} , MOB_{jt}	Mobile phone subscriptions of Bangladesh and country j in year t	Subscriptions per 100 inhabitants	ITU
BRB_{it} , BRB_{jt}	Broadband subscriptions of Bangladesh and country j in year t	Subscriptions per 100 inhabitants	ITU
GDP_{it}, GDP_{jt}	GDP of Bangladesh and country j in year t	Current USD(millions)	WDI
$DIST_{ij}$	Physical distance between Bangladeh and country j in kilometers	Kilometres	French Research Centre in International Economics (CEPII)
RTA_{ijt}	Bangladesh and country j are part of the same Regional Trade Agreement (Yes =1, No =0)		WTO RTA database
$COMBOR_{ij}$	Bangladesh and country j share the same border (Yes =1, No =0)		CEPII
$LANDLOCKED_j$	Country j is a landlocked (Yes =1, No =0)		CEPII
EU_j	Country j is a member of EU link (Yes =1, No =0)		WTO RTA database
$NAFTA_j$	Country j is a member of NAFTA link (Yes =1, No =0)		WTO RTA database
$BRICS_j$	Country j is a member of BRICS (Yes =1, No =0)		WTO RTA database
ε_{ijt}	The error term		

Table A2. Summary statistics.

Variable	Obs	Mean	Std. Dev.	Min	Max
Exp_{ij}	1883	146.804	473.413	0.02	4428.72
ln Exp_{ij}	1883	2.282	2.486	-3.912	8.396
Ln $IU_{i.t-1}$	1.944	0.467	1.846	-2.642	2.892
Ln $BRB_{i.t-1}$	1.188	-0.634	1.686	-3.485	1.517
Ln $MOB_{i.t-1}$	1.944	2.602	2.0125	-1.527	4.548
Ln ($IU_{i.t-1}$*$IU_{j.t-1}$)	1928	3.289	3.127	-10.191	7.479
Ln ($BRB_{i.t-1}$*$BRB_{j.t-1}$)	1159	0.692	3.168	-11.931	5.355
Ln ($MOB_{i.t-1}$*$MOB_{j.t-1}$)	1936	6.474	3.18	-5.502	10.077
Ln(GDP_{it}*GDP_{jt})	2021	50.61	2.117	44.603	57.012
ln$DISTANCE_{ij}$	2052	8.657	0.658	6.066	9.808
$RTA_{ij.t-1}$	1944	0.343	0.475	0	1
$COMBOR_{ij}$	2052	0.019	0.135	0	1
$LANDLOCKED_{j}$	2052	0.093	0.29	0	1
EU	2052	0.25	0.433	0	1
NAFTA	2052	0.028	0.164	0	1
BRICS	2052	0.046	0.21	0	1